AD-A015 054

EXPECTED PERFORMANCE OF REAL-TIME INTERACTIVE SYSTEM

Stephen S. Lane

Texas Instruments, Incorporated

Prepared for:

Advanced Research Projects Agency
Air Force Technical Applications Center

16 July 1975

ALEX(01)-TR-75-09

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TECHNICAL REPORT NO. 9

VELA NETWORK EVALUATION AND AUTOMATIC PROCESSING RESEARCH

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Prepared for

AIR FORCE TECHNICAL APPLICATIONS CENTER
AFTAC Project No. VELA T/5705/B/ETR
Alexandria, Virginia 22314

Sponsored by

ADVANCED RESEARCH PROJECTS AGENCY
Nuclear Monitoring Research Office
ARPA Program Code No. 5F10
ARPA Order No. 2551

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Acknowledgment: This research was supported by the Advanced Research Projects Agency, Nuclear Monitoring Research Office, under Project VELA-UNIFORM, and accomplished under the technical direction of the Air Force Technical Applications Center under Contract Number F08606-75-C-0029.

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UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EXPECTED PERFORMANCE OF REAL-TIME INTERACTIVE SYSTEM		5. TYPE OF REPORT & PERIOD COVERED Technical
		6. PERFORMING ORG. REPORT NUMBER ALEX(01)-TR-75-09
7. AUTHOR(s) Stephen S. Lane		8. CONTRACT OR GRANT NUMBER(s) F08606-75-C-0029
9. PERFORMING ORGANIZATION NAME AND ADDRESS Texas Instruments Incorporated, Equipment Group, Dallas, Texas 75222		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS VELA T/5705/B/ETR
11. CONTROLLING OFFICE NAME AND ADDRESS Advanced Research Projects Agency, Nuclear Monitoring Research Office, Arlington, Virginia 22209		12. REPORT DATE 16 July 1975
		13. NUMBER OF PAGES 8
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Air Force Technical Applications Center, VELA Seismological Center, Alexandria, Virginia 22314		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE, DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

ARPA Order No. 2551

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Seismology
Interactive seismic processing
Complex cepstrum

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This memorandum describes the expected real-time performance of an interactive long-period seismic processing system and of an interactive complex cepstrum program, both utilizing a graphic output. It was found that a highly automated system could probably process seismic events in real-time, although the operators attention span would be limited to about 2 hours. The interactive complex cepstrum, however, could not be used for events in real-time, and its graphic display was of little value to an experienced operator.

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MEMORANDUM - Technical Report No. 9 16 July 1975

TO : Ralph W. Alewine, III

FROM : Stephen S. Lane, Texas Instruments Incorporated

SUBJECT: Expected Performance of Real-Time Interactive System

This memorandum describes the expected real-time performance of the interactive seismic processing system (ISPS) and the interactive cepstrum program implemented on the PDP-15/50 computer at the Seismic Data Analysis Center. By real-time it is meant that events are written as they are recorded onto the computer disk. Therefore I/O time requirements are small and events appear on the disk at irregular times.

1. Interactive Seismic Processing System

ISPS is designed to perform standard processing on a long-period seismic trace of 4096 seconds sampled at 2 second intervals. Although little time is required to load such a trace onto the disk, if it is in field-tape format the PDP-15/50 cannot decode it and simultaneously process other events, due to machine size limitations. About 5 seconds are required for decoding typical long-period traces, so this task could be done by preempting the machine when an event arrives at the computing center.

At present the ISPS can perform all processing ordinarily desired by an analyst in 5 to 8 minutes for each long-period trace. This processing includes the application of a bandpass filter, 5 chirp filters and a master event filter, and calculation of surface wave magnitude. A plot tape of the raw traces, the bandpassed trace, the master event filtered trace, the best chirp filtered trace, and some annotation can be generated during the same time interval. Plotting this information takes about the same time as is required to generate it, and can be done by the same machine while processing later events.

With the present system an operator could process between seven and twelve single traces per hour. It is estimated that after about 4 hours of such work the analyst's efficiency would be impaired by the monotonous nature of the processing.

It is unlikely that this processing rate would be adequate in a surveillance system, especially if more than one trace per event was to be examined. The limiting factor in the system at present is the time required for operator interaction, because the operator must initiate each processing step, and enter the values of any parameters required, such as chirp filter lengths. The capacity of the system could be increased substantially without losing any capability by raising the level of automation.

Under full automation, the system would make each measurement described above and display each trace but would use preassigned parameters and would not require operator interaction. The only operator intervention would occur when he believed, on the basis of the displayed traces, that the algorithm was making an error. At this point he would take appropriate measures to prevent incorrect information from entering the output file.

One trace could be processed under this system in about 30 seconds computation time plus the time required to view the traces, which should be no more than 2 minutes, raising the number of events processed per hour to about 24. A lower degree of automation would of course require longer processing times.

At the highest automation level we estimate than an operator could perform efficiently for only about 2 hours, due to his lack of involvement with the work. At this event processing rate the plotting capacity of the present system would be exceeded. As alternative solutions to this problem, either less information could be presented in each plot or another machine used for this task.

2. Complex Cepstrum

The PDP-15/50 program which implements the complex cepstrum follows that used by Texas Instruments Incorporated on the IBM 360/44. For a real-time system the waveform, of length up to 20 seconds digitized at 10 points per second, would be present on disk. Processing parameters would be entered by the operator.

There are three points in the processing sequence where operator intervention is required. They are:

- Initially, when the start and stop point of the input trace is chosen
- After the cepstrum is calculated, when the filter point is chosen
- After filtering, when a conclusion is drawn as to the success or failure of the filtering.

In general a much longer time is required to examine the results than to produce them. Thus, utilization of the computer is low for the complex cepstrum. Consequently, the time required to process a single short-period arrival varies with the operator's experience and with the complexity of the motion. To extract a depth phase from a simple presumed explosion waveform might require 5 minutes in all. When the nature of the event is not known but is to be determined, much greater time is required. For example, to extract three direct arrivals and to search for their depth phases in a single presumed explosion trace has required as much as 45 minutes. The great majority of this time was spent examining traces and attempting to make judgments about the similarity between various waveforms. Even more time is usually spent on the more complicated signals from earthquakes. It is very important that such examinations be made, because an incorrect separation at any point in the processing will invalidate the following results.

A difficulty with the present system arises when it is required to compare traces on the screen with those that may exist only in the form of line printer output. This will happen when the last of three waveforms is extracted from a mixed signal, and the analyst desired to compare it to the first. No alternations to the program could improve this situation, which now requires sorting through the hard-copy output and comparing to the screen display.

The interactive system represents an improvement over batch processing in that the analyst can rapidly try various weighting factors and filter points. Part of this advantage disappears as the analyst becomes more experienced, however. Probably for a highly skilled analyst the graphic display of the system provides no advantage, and all the advantages of the total system could be obtained from a processor which was interactive but had only hard-copy output. Even in this case the complex cepstrum, due to the long times required for examination of the results, could not be used in a real-time mode except perhaps for the very simplest cases.